

WHAT IS CLAIMED IS:

1. An apparatus for identifying a buried object using array-based ground
penetrating radar having a control device, a plurality of transmit antennas, and a
plurality of receive antennas, said control device receiving a transmit timing input
5 signal and a receive timing input signal, said apparatus comprising:

a first delay circuit receiving the transmit timing input signal and generating a
number of intermediate transmit timing signals delayed with respect to each other by a
delay time;

transmit output switch circuit to select either the transmit timing input signal or
10 a corresponding one of the intermediate transmit timing signals as a corresponding
output transmit timing signal;

a second delay circuit receiving the receive timing input signal and generating a
number of intermediate receive timing signals delayed with respect to each other by the
delay time;

15 a shift-delay circuit coupled to the second delay circuit and the receive timing
input signal to add the delay time to the intermediate receive timing signals; and

receive output switch circuit to select either the receive timing input signal or a
corresponding one of the intermediate receive timing signals as a corresponding output
receive timing signal.

20 2. The apparatus of claim 1, further comprising
an element to trigger one of the plurality of transmit antennas to transmit
dependent on the output transmit timing signal; and

an element to trigger one of the plurality of receive antennas to sample a
received waveform dependent on the output receive timing signal.

25 3. The apparatus of claim 2, further comprising a monostatic data acquisition
controller.

4. The apparatus of claim 2, further comprising a multistatic data acquisition controller.

5. The apparatus of claim 1, further comprising
a first comparator wherein the transmit timing input signal is derived by
5 comparing a common timing signal to a transmit threshold signal, and
a second comparator wherein the receive timing input signal is derived by
comparing the common timing signal to a receive threshold signal.

6. The apparatus of claim 1, wherein the first delay circuit comprises a first
plurality delay elements, the second delay circuit comprises a second plurality of delay
10 elements, and the shift-delay circuit comprises a shift-delay element.

7. The apparatus of claim 6, wherein all the delay elements are of the same value.

8. The apparatus of claim 1, wherein the apparatus further comprises a mobile housing for moving the apparatus along terrain under which the object is buried.

15 9. The apparatus of claim 8, wherein the housing is suitable for being hand-held by an operator.

10. A method for identifying a buried object using array-based ground penetrating radar having a control device, a plurality of transmit antennas, and a plurality of receive antennas, said control device receiving a transmit timing input
20 signal and a receive timing input signal, the method comprising:
generating a plurality of intermediate transmit timing signals by delaying the transmit timing input signal by a plurality of delay times;
selecting either the transmit timing input signal or a corresponding one of the intermediate transmit timing signals as a corresponding output transmit timing signal;
25 generating a number of intermediate receive timing signals by delaying the receive timing input signal by the plurality of delay times; and

selecting either the receive timing input signal or a corresponding one of the intermediate receive timing signals as a corresponding output receive timing signal.

11. The method of claim 10, further comprising adding a second delay time to the intermediate receive timing signals.

5 12. The method of claim 10, further comprising
triggering one of the plurality of transmit antennas to transmit dependent on the output transmit timing signal; and
triggering one of the plurality of receive antennas to sample a received waveform dependent on the output receive timing signal.

10 13. The method of claim 12, further comprising acquiring data with a monostatic data acquisition controller.

14. The method of claim 12, further comprising acquiring data with a multistatic data acquisition controller.

15 15. The method of claim 10, further comprising
comparing a common timing signal to a transmit threshold signal to derive the transmit timing input signal; and
comparing the common timing signal to a receive threshold signal to derive the receive timing input signal.

20 16. An apparatus for identifying a buried object using array-based ground penetrating radar having an antenna array, said antenna array comprising:
a plurality of transmit antennas linearly arranged;
a plurality of receive antennas linearly arranged and parallel to the transmit antennas; and
means for selectively enabling the transmit and receive antennas to allow each
25 of the receive antennas to receive energy from any one of the transmit antennas.

17. The apparatus of claim 16, wherein each receive and transmit antenna has the same width and each receive antenna is aligned with a corresponding one of the plurality of transmit antennas, but offset in the linear direction one half the width of the antennas.

18. The apparatus of claim 16, wherein a plurality of the transmit antenna each have an impulse generator and a high-voltage generator.

19. The apparatus of claim 16, wherein a plurality of the receive antennas each have a sample and hold amplifier and an analog to digital converter.

20. The apparatus of claim 16, wherein two positioning devices are used to determine a direction of movement.

21. The apparatus of claim 16, wherein a plurality of receive antenna transmits digital data to a control unit simultaneously.

22. A control device for an impulse radar having a plurality of transmit antennas and a plurality of receive antennas, said control device receiving a transmit timing input signal and a receive timing input signal, comprising:

a first delay circuit receiving the transmit timing input signal and generating a number of intermediate transmit timing signals delayed with respect to each other by a delay time;

transmit output switch circuit to select either the transmit timing input signal or a corresponding one of the intermediate transmit timing signals as a corresponding output transmit timing signal;

a second delay circuit receiving the receive timing input signal and generating a number of intermediate receive timing signals delayed with respect to each other by the delay time;

a shift-delay circuit coupled to the second delay circuit and the receive timing input signal to add the delay time to the intermediate receive timing signals; and

receive output switch circuit to select either the receive timing input signal or a

corresponding one of the intermediate receive timing signals as a corresponding output receive timing signal.

23. The control device of claim 22, further comprising
an element to trigger one of the plurality of transmit antennas to transmit
5 dependent on the output transmit timing signal; and
an element to trigger one of the plurality of receive antennas to sample a
received waveform dependent on the output receive timing signal.

24. The control device of claim 23, further comprising a monostatic data acquisition controller.

- 10 25. The control device of claim 23, further comprising a multistatic data acquisition controller.

26. The control device of claim 22, further comprising
a first comparator wherein the transmit timing input signal is derived by
comparing a common timing signal to a transmit threshold signal, and
15 a second comparator wherein the receive timing input signal is derived by
comparing the common timing signal to a receive threshold signal.

27. The control device of claim 22, wherein the first delay circuit comprises a first plurality delay elements, the second delay circuit comprises a second plurality of delay elements, and the shift-delay circuit comprises a shift-delay element.

- 20 28. The control device of claim 27, wherein all the delay elements are of the same value.

29. The control device of claim 22, wherein the control device further comprises a mobile housing for moving the control device along terrain under which the object is buried.

30. The control device of claim 29, wherein the housing is suitable for being hand-held by an operator.

31. An apparatus for identifying a buried object using array-based ground penetrating radar having a control device, a plurality of transmit antennas, and a plurality of receive antennas, said control device receiving a transmit timing input signal and a receive timing input signal, the apparatus comprising:

means for generating a plurality of intermediate transmit timing signals by delaying the transmit timing input signal by a plurality of delay times;

means for selecting either the transmit timing input signal or a corresponding one of the intermediate transmit timing signals as a corresponding output transmit timing signal;

means for generating a number of intermediate receive timing signals by delaying the receive timing input signal by the plurality of delay times; and

means for selecting either the receive timing input signal or a corresponding one of the intermediate receive timing signals as a corresponding output receive timing signal.

32. The apparatus of claim 31, further comprising means for adding a second delay time to the intermediate receive timing signals.

33. The apparatus of claim 31, further comprising means for triggering one of the plurality of transmit antennas to transmit dependent on the output transmit timing signal; and

means for triggering one of the plurality of receive antennas to sample a received waveform dependent on the output receive timing signal.

34. The apparatus of claim 33, further comprising means for acquiring data with a monostatic data acquisition controller.

35. The apparatus of claim 33, further comprising means for acquiring data with a multistatic data acquisition controller.

36. The apparatus of claim 31, further comprising
means for comparing a common timing signal to a transmit threshold signal, to
derive the transmit timing input signal; and
means for comparing the common timing signal to a receive threshold signal to
5 derive the receive timing input signal.

37. The apparatus of claim 31, wherein the first delay circuit comprises a first
plurality delay elements, the second delay circuit comprises a second plurality of delay
elements, and the shift-delay circuit comprises a shift-delay element.

38. The apparatus of claim 37, wherein all the delay elements are of the same
10 value.

39. The apparatus of claim 31, wherein the apparatus further comprises a
mobile housing for moving the apparatus along terrain under which the object is buried.

40. The apparatus of claim 39, wherein the housing is suitable for being hand-
held by an operator.

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